REGULATORY COMPETITION*

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ABSTRACT. In this article, I consider a simple spatial model of regulatory competition in which a firm competes for customers on a rival firm's domestic market. In this setting, two regulators control their interdependent markets in order to maximize welfare in each their own jurisdiction. I show that the failure of a regulator to internalize the effects that local regulation has on consumers and producers outside its own jurisdiction, may render regulation suboptimal in equilibrium. I show that even when the unregulated laissez faire outcome is socially optimal, regulation decreases welfare. This is thus an instance of equilibrium over-regulation. I show that domestic regulation need not be a beggar-thy-neighbor policy and that the regulators' interaction is never a prisoner's dilemma.
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1. INTRODUCTION

The international economy increasingly relies on specialization and trade within and between countries and trading blocks and has undergone a concerted effort at codification through the World Trade Organization to ensure the smooth and efficient functioning of international markets. Within the framework of the WTO, explicit trade barriers such as tariffs and quotas and indirect trade impediments such as export subsidies, have been gradually removed. As a consequence, both policy and academic attention has shifted towards alternative policies that, although not trade barriers in name, have similar effects in curtailing trade across jurisdictions.

In particular, there has been an increased interest in such so-called "behind-the-border" measures (see Brown and Crowley, 2016 and Ederington and Ruta, 2016 for surveys). These measures, also known as BTB, consist of domestic regulatory interventions, such as production subsidies or taxes, that directly or indirectly influence trade flows. There are many different justifications that can be given for offering subsidies to domestic producers, from the wish to shift profits between producers (say, from foreign to domestic firms) to the more benign aim to correct domestic market imperfections, as a regulator under autarky might do. Accordingly, WTO regulations do not rule out domestic subsidies per se, unless they can be shown to *displace* like products that would otherwise be imported from another member country (see Coppens, 2013 for a detailed discussion of WTO rules on subsidies).

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For a concrete example, consider the high-stakes game played between the European Union and the United States at the WTO over the market for large civil aircraft (see Dixit and Kyle, 1985 for an early treatment). The US has complained that the EU and several of its member states have illegally subsidized the European aircraft maker Airbus at the expense of its US based competitor Boeing. In response, the EU has complained that the US has similarly subsidized Boeing. The case has been running for years and is expected to conclude with the WTO ruling out some subsidies on both sides.

From a theoretical perspective, this case raises a number of pertinent questions. First, are there legitimate domestic reasons for offering such subsidies, say to overcome market imperfections? Second, how do such domestic policies influence trade patterns? Third, are such subsidies necessarily to the detriment of the foreign country (as opposed to the foreign firm)? Fourth, what are the equilibrium regulatory choices and trade patterns when both sides can adopt such policies and what are the ultimate effects of these choices on aggregate welfare? Last, under what circumstances would the EU and the US agree to a framework under which such domestic subsidies are removed? Would all parties be better off under such an institution or would transfers be needed to ensure participation from all sides?

The reason that the answers to these questions are not trivial is that even if subsidies to the foreign firm displaces domestic production (which may hurt the domestic firm), they also benefit domestic consumers through lower prices. Thus the effects on overall domestic welfare are ambiguous. To this should be added that the foreign policy intervention can change the domestic regulator's incentives to likewise intervene in the domestic market. These are the type of questions that this article seeks to address.

Despite significant advances in our knowledge of both regulation without market interdependencies the strategic issues embedded in the formulation of trade policy, there remain important open questions. Summarizing the state of the literature on behind-the-border measures, Brown and Crowley (2016) state that

> "[...] the next major area for the world trading system involves confronting the balance of respecting local preferences, internalizing cross-border policy externalities that arise through trade, and yet integrating economic activity across borders so as to make the most productive use of global resources. And yet not surprisingly, our main result [...] is that much more theoretical, empirical, and quantitative research is needed before we can systematically characterize in any meaningful way the trade restrictiveness, or levels of import protection, associated with BTB policies."

To make progress in understanding such measures, I analyze a simple model of competition between two regulators tasked with overseeing firms in an interdependent market. The basic environment is that of the linear city of Hotelling (1929). Two firms are located on the line and compete for consumers who have linear transport costs. The market is exogenously divided into two separate jurisdictions, each controlled by a separate regulator who seeks to maximize welfare in its jurisdiction. Within this setting, I study the following two stage game. At the first stage, the two regulators simultaneously decide on regulatory regimes. In particular, a regulator can decide to regulate (in which case it directly controls the firm's price with a view to maximize social welfare in its jurisdiction) or to not regulate (in which case the firm is left free to maximize its profits). At the second stage, the two firms' prices are set according to the regime choices made by the regulators at the first stage. I analyze subgame perfect equilibria in pure strategies and find that there are two equilibrium outcomes, depending on the size of the countries. When the exporting country is sufficiently large, its firm is regulated whereas the importing country's firm is not. When the exporting country is sufficiently small, both countries regulate their firms. I find that although domestic regulation benefits consumers at the expense of firms, it decreases aggregate welfare. I show that regulation by a country's regulator may (but need not) decrease welfare in the rival country and that whether this is the case depends on the relative size of the markets. Thus regulation may (but need not) be a beggar-thy-neighbor policy. Last, I show that the game played between the regulators is not a prisoner's dilemma. This implies that a free-trade agreement in which no firm is regulated, is only feasible if one country makes a transfer to the other country. Such a transfer is needed to compensate it for the change in the terms of trade brought about by the free-trade agreement.

1.1. Related literatures. The present article relates to several distinct literatures. First, it contributes to the literature on inter-jurisdictional competition and regulation. This is a varied literature that includes the analysis of merger control (Barros and Cabral, 1994), banking regulation (DellAricci and Marquez, 2006 and Spatt, 2006), the regulation of electricity markets (Neuhoff and Newbery, 2005), environmental regulation (Oates and Schwab, 1988 and Oates, 2001 and references therein), tax competition (Tiebout, 1954 and more recent articles) and restrictions on international lobbying (Aidt and Hwang, 2014). See also Wellisch (2000) for a review of public finance in inter-jurisdictional settings. In the context of the European Union, there is interdependent regulation in the markets for electricity and gas, audiovisual media services, electronic communications, pharmaceuticals etc. More generally, policy mis-coordination (e.g. between fiscal and monetary policy within an administration) has received ample attention in the policy literature.

Second, some of the issues considered in this article have close parallels with those studied in the literature on strategic delegation, such as Vickers (1985), Fershtman and Judd (1987) and Skliva (1987). In that literature, firm owners offer contracts to managers that give the latter incentives that are not necessarily profit maximization. The reason that they do this, despite the practice potentially decreasing profits in equilibrium, is that it is a best response to owners of rival firms behaving in this way. In the strategic delegation literature, players typically wish to commit to being less aggressive when choice variables are strategic complements (such as under Bertrand competition) and to being more aggressive when they are strategic substitutes (such as under Cournot competition). In the present model, this result will be turned on its head. Specifically, regulators may choose to "delegate" the decision of pricing to the firm, even though the firm seeks to maximize profits, rather than to maximize social welfare in the regulator's jurisdiction. The reason that it may be valuable for the regulator to commit to pricing like a profit maximizer, rather than to seek to maximize domestic social welfare ex post, is precisely because such commitment ex ante allows the regulator to reach preferred outcomes ex post that it would not otherwise be able to reach.

Third, the article also contributes to a large and important literature on strategic trade theory (see e.g. Brander, 1995 for a survey). In particular, Brander and Spencer

(1985), Eaton and Grossman (1986) and Cheng (1988) investigate the nature of optimal trade taxes/subsidies and their dependence on the nature of competition. They show that under Bertrand competition with differentiated products, countries may find it optimal to impose taxes on exporting firms, thereby helping them commit to higher prices than what would be feasible under laissez-faire. Such taxes increase equilibrium prices and are unambiguously welfare increasing in the settings they consider. Under Cournot competition, many of these findings are reversed. In particular, a production subsidy may help a firm commit to increased output levels, at the expense of the competing firm, by enabling the shifting of profits. When such a subsidy policy is pursued by both competing countries, the subsidized equilibrium outcome can yield lower aggregate welfare than the free-trade equilibrium. These properties closely mirror those found in the strategic delegation literature. Many contributions to the strategic trade literature make use of the so-called third-country model, introduced by Brander and Spencer (1985). In the simplest version of this model, two firms produce from two separate countries, but sell in a third country. Whereas the exporting countries have no consumers of their own, the third country has consumers but no own production. The third-country model is a convenient way to sidestep the tradeoffs between consumer and producer surplus within countries.

In the present model the regulators generally prefer lower prices, in the process inducing decreased overall welfare. So even though I consider price setting behavior, the equilibrium outcomes are more akin to those usually associated with quantity setting. Dixit (1984, 1988) explicitly considers the interdependence of industrial and trade policy, whereas most of the strategic trade literature bypasses the issue of correcting for distortions due to imperfect competition on the domestic market. In this respect, the present work is closely related to that of Dixit, as I treat regulatory and trade policy as inextricably linked, with policies influencing the home country also influence the interaction with the other country and vice versa.

My work shows that a reasonable departure from the third-country model entirely reverses received wisdom in terms of policy prescriptions. In particular, I show that if economic regulators take domestic consumer surplus into account in assessing the optimality of different policy options, then the (privately) optimal thing to do may be to offer export enhancing domestic production subsidies even under price competition, rather than to impose export taxes as suggested by the existing literature.

The main differences between the strategic delegation and trade literatures and the present work is this: In the strategic delegation literature, there is no intrinsic difference in objectives between the decision maker and the delegator. The latter may distort the former's incentives away from profit maximization in order to overcome a commitment problem, but this problem would cease to exist in a non-strategic setting in which there were no competition against third parties. This property is shared by the simplest versions of the third-country models in the strategic trade literature. In contrast, in my setting, both countries have both consumers and producers and therefore the regulators have different objectives than the firms they regulate, even in the absence of strategic consternations arising from competition with the rival countries.

A number of articles consider settings in which a domestic market is served by both a domestic producer and by imports from a foreign producer (in a country without consumers of its own). Articles in this tradition include Brander and Spencer (1881), Rieber

(1982), Dixit (1984, 1988), Cheng (1988), Collie (1991) and Kohler and Moore (2003). Of particular relevance to the present work are so-called subsidy games, i.e. strategic trade models of international oligopolies in which governments compete in subsidy schemes. Important contributions to this literature include Neary (1994), Leahy and Neary (2009) and Neary and Leahy (2000).

Last, a small literature studies trade issues in location models, e.g. Tharakan and Thisse (2002) and Collie and Clarke (2003), but it does not consider policy issues. The market model employed in the present analysis has some features in common with so-called inside-outside spatial competition models considered by Tabuchi and Thisse (1995), Lambertini (1997) and Toh and Poddar (2006), although these authors do not consider issues of regulation.

As outlined above, there is a very large literature on the consequences of inter-jurisdictional economic competition and regulation that analyzes situations in which multiple regulators can each influence economic activity in separate jurisdictions, but where agents are either free to choose between jurisdictions or where firms in each jurisdiction are free to engage in economic activity in other jurisdictions. One can identify three broad themes in this literature. First, there are results in the tradition of Tiebout (1956). Writing on the determinants of local government expenditures, Tiebout envisioned local governments or authorities competing with each other to attract voters and businesses. The level of expenditure, or the regulatory framework in place, can be seen as the means by which a local government can differentiate itself from its peers. According to this view, regulatory competitions may have beneficial effects as it induces efficient outcomes. Second, many authors find that competition between economic or environmental regulators induces suboptimally low levels of regulation. In such settings, there is usually too little regulation in equilibrium, because each regulator ignores the benefits of their interventions that accrue to individuals outside their jurisdictions, as will typically be the case with environmental regulation of emissions and pollution. In such situations, competition may entail a *race to the bottom*, with regulators outbidding each other through ever more lenient regulation of firms in its jurisdiction, leading to detrimental welfare effects in adjacent jurisdictions. Last, there are analyses that show that with suboptimal tools, even a central planner would not be able to correct for the suboptimal levels of regulation created by decentralization (see Oates, 2001). In contrast to these broad types of the results, one of the main findings of the present analysis is that regulatory competition, rather than inducing efficiency or being insufficient in bringing about efficient outcomes, may itself be the source of economic inefficiencies. This suggests that rather than seeking to enhance the tools or extent of regulation, in some situations it is pertinent to enhance the regulatory framework itself.

The remainder of the article is structured as follows. In Section 2, I present the basic model. In Section 3, I analyze two benchmarks, namely the solution under autarky and the command optimum. In Section 4, I analyze the equilibrium outcomes of the regulatory competition model. In Section 5, I extend the analysis to the case of price discrimination and in Section 6, I discuss implementation through taxes and subsidies and contrast the model to the third-country model. In Section 7, I conclude. The Appendix contains details omitted in the main text.

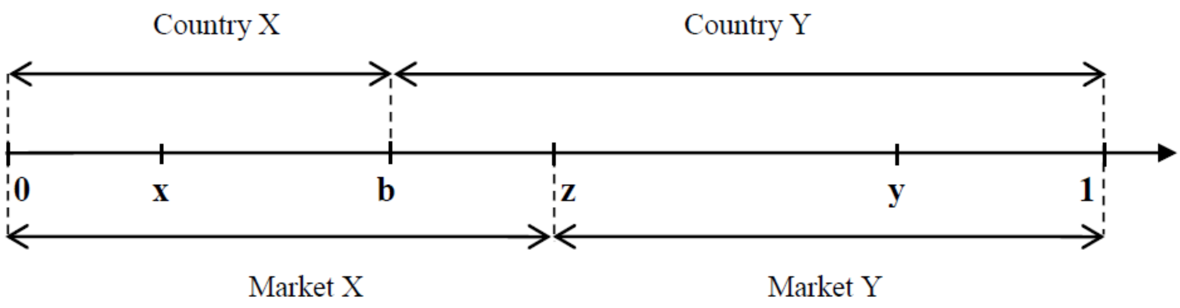

Figure 1: Regulatory jurisdictions, firm locations and market shares.

2. THE MODEL

Consider a Hotelling city of unit length, with consumers uniformly distributed along it with density one. Consumers have unit demand and incur a linear transport cost of ks (with $k \geq 0$) for distance s to the location of the firm whose product they patronize. The consumers enjoy utility

$$u = \begin{cases} v - p - ks & if \quad p \leq v - ks \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

where $v > 0$ is the gross utility of consumption and p is the price charged by the supplying firm. Let two firms be located at points x and y respectively, where $0 < x < y < 1$. These locations are exogenously given. The firms have constant marginal costs c_X and c_Y and set prices p_X and p_Y, respectively. These prices determine the location of the indifferent consumer

$$z \equiv \frac{p_Y - p_X + k(x + y)}{2k} \tag{2}$$

The firms face demands $q_X = z$ and $q_Y = (1-z)$ and earn profits $\pi_i = (p_i - c_i)q_i$, $i = X, Y$ respectively. Note that I am implicitly assuming that the market is fully covered.

A border $b \in (x, y)$ separates the market into a Country X of size b and a Country Y of size $(1 - b)$. I assume without loss of generality that

$$x < b < z < y \tag{3}$$

This means that Country X is exporting to Country Y. It will turn out later that the relative country size b has important effects on equilibrium behavior. The setup is represented graphically in Figure 1.

Next, consider two regulators X and Y who seek to maximize social welfare in the X and Y country respectively. Consumer surplus for the two countries is given by

$$cs_X = \int_0^x (\upsilon - p_X - ks)ds + \int_0^{b-x} (\upsilon - p_X - ks)ds \tag{4}$$

$$cs_Y = \int_{b-x}^{z-x} (\upsilon - p_X - ks)ds + \int_0^{y-z} (\upsilon - p_Y - ks)ds + \int_0^{1-y} (\upsilon - p_Y - ks)ds \tag{5}$$

The segments $[0, x]$ and $[x, b]$ constitute Firm X's home turf, whereas the segment $[y, 1]$ constitutes Firm Y's home turf. The segment $[b, y]$ is the competitive segment, with $[b, z]$ accruing to Firm X and $[z, y]$ accruing to Firm Y. Note that $[b, z]$ constitutes Country X's exports to Country Y (i.e. goods produced by Firm X but consumed by consumers of Country Y).[1]

Let social welfare in country $i = X, Y$ be denoted by $w_i = \pi_i + cs_i$ and overall welfare by $W = w_X + w_Y$.

In order to make the problem interesting and ensure that the two firms are in actual competition (i.e. that the competitive segment is non-empty), I assume that

$$\upsilon \geq \max\{c_X, c_Y\} + 2k(y - x) \tag{6}$$

2.1. The Game. The timing of the game is as follows: At stage 1, the two regulators simultaneously choose actions a_X, a_Y in the spaces $A_X = \{R, N\}$ and $A_Y = \{R, N\}$, respectively. These actions correspond to choosing between *regulating* and *not regulating*. At stage 2, the firms play the market game simultaneously, given the regulatory regime resulting from the decisions made at stage 1. At the market stage, the regulatory regimes put in place at the previous stage are common knowledge. When a regulator chooses to regulate, he sets a price so as to maximize welfare in his country. That is, if Regulator $i = X, Y$ chooses to regulate, he solves the problem

$$\max_{p_i \geq 0} \{w_i\} \tag{7}$$

and instructs Firm i to set the resulting welfare maximizing price.

If instead Regulator i chooses not to regulate, then Firm $i = X, Y$ solves the problem

$$\max_{p_i \geq 0} \{\pi_i\} \tag{8}$$

Although I mainly work under the assumption that regulation involves the regulator's direct control of the firm's price, I show in Section 6 how the exact same outcomes can be implemented by subsidizing/taxing production.[2] Throughout, second-order conditions hold and thus first-order conditions are sufficient for optimality.

Note that given a regulatory regime chosen by the two regulators at stage 1, the

[1] In writing up the expressions for consumer surplus, I make use of the fact that there is full market coverage, i.e. that the consumers located at 0 and 1 are served. Coverage issues in location models is the central focus of Tharakan and Thisse (2002).

[2] It should be noted that I implicitly assume that no firm may engage in price discrimination, either between its own country's consumers or between these and the other country's consumers. That is, all consumers, whether domestic or foreign, face the same mill price from a given firm. This assumption is relaxed in Section 5.

relevant stage 2 reaction functions will uniquely determine the equilibrium prices and thus stage 1 payoffs. What the regulators are doing at the regime choice stage, is essentially to commit to one of two possible market stage reaction functions each (namely that of the firm versus that of the regulator). The problem faced by the regulators when committing to regulatory regimes, is akin to the problem faced by firm owners when designing managerial incentives in problems of strategic delegation or by governments choosing trade policies in oligopolistic international markets.

Throughout, regime (i, j) will refer to the case in which Regulator X chooses regime $i = N, R$ and Regulator Y chooses regime $j = N, R$. I will make use of the shorthand notation $W(i, j)$ for the value of aggregate welfare accruing at the market stage in the subgame induced by the regime choice (i, j) and similar notation will be used for other quantities of interest.

The normal form of the game played by the two regulators at stage 1 is shown in the following matrix:

	$a_Y = N$	$a_Y = R$
$a_X = N$	$w_X(N, N), w_Y(N, N)$	$w_X(N, R), w_Y(N, R)$
$a_X = R$	$w_X(R, N), w_Y(R, N)$	$w_X(R, R), w_Y(R, R)$

The incentives of the firms and the regulators are, by nature, not perfectly aligned. This is most clearly seen in Figure 2, which plots the indifference curves in (p_X, p_Y)-space. The left-hand side panel shows the indifference map of Firm X (in solid lines) and of Regulator X (in dashed lines). It is evident that although the objectives of the actors in the exporting country are not perfectly aligned, their incentives are not very different either. The right-hand side panel shows the indifference map of Firm Y (in solid lines) and of Regulator Y (in dashed lines). It is clear that in the importing country, the actors' incentives are quite different. In Appendix B, I derive the most preferred points for the two firms.

It should be emphasized that the level sets for Regulator Y's objective are in general not well-behaved, in the sense that when the parameters of the model are changed, the indifference curves may cease to be nicely convex to the origin and may even become disconnected. An example of this is shown in Figure 4 below.

Last, it will be assumed throughout that for any given regime (i, j), $i, j = N, R$, the indifferent consumer is located so $z(i, j) \in [b, y]$. This assumption implies that the regime choices do not determine the identity of the exporting and the importing country. Sufficient conditions for this to be the case are provided in Appendix A for the special case in which firms are symmetric both in terms of locations and in terms of marginal costs.

3. TWO BENCHMARKS

To better appreciate the details of the equilibria of the game, I start by briefly considering two benchmarks, namely the outcome under autarky, in which there is no trade between jurisdictions and the solution preferred by a utilitarian social planner.

3.1. The Autarkic Solution. Under autarky, the firms are constrained to quantities $q_X \leq b$ and $q_Y \leq (1 - b)$, respectively. Assuming that there is full market coverage, the

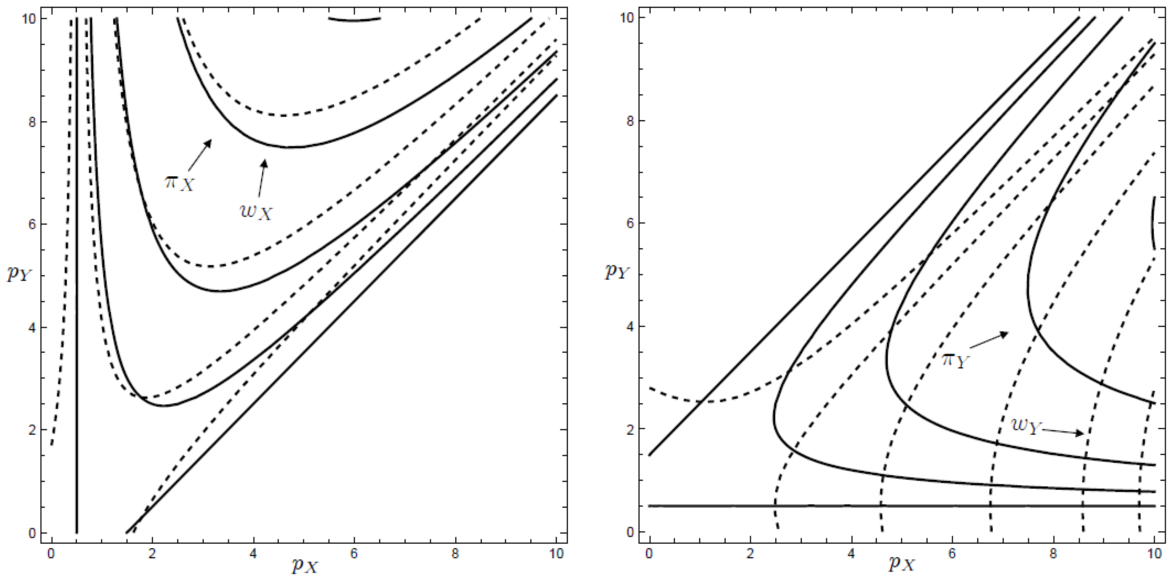

Figure 2: Indifference maps of firms and regulators in (p_X, p_Y)-space at market stage. The arrows indicate the directions of increase in the different objectives. Solid curves represent curves firms and dashed curves represent regulators. Left-hand side panel corresponds to Country X and right-hand side panel corresponds to Country Y.

firms will profit maximize by setting prices such that the most distant consumers within their respective markets just break even. Thus the equilibrium prices are given by

$$p_X^A = \upsilon - k\max\{x, b - x\} \tag{9}$$
$$p_Y^A = \upsilon - k\max\{y - b, 1 - y\} \tag{10}$$

In order to avoid issues of market coverage, I will assume throughout that the parameters of the model are such that under autarky, either firm would voluntarily choose to cover its entire market.[3] A sufficient condition for this to be the case, is that

$$\upsilon \geq \max\{c_X + 2\max\{x, b - x\}, c_Y + 2\max\{1 - y, y - b\}\} \tag{11}$$

For later use, note that under autarky, any prices are constrained socially optimal in the sense that given that quantities and travel costs are independent of the chosen prices, prices only determine the distribution of surplus between producers and consumers and have no impact on total social surplus within each jurisdiction. Of course, the solution under autarky does not maximize overall surplus, bar a stroke of luck. This is because the consumers are restricted to buying from their respective home suppliers, thus making aggregate travel costs suboptimally high.

3.2. The Socially Optimal Solution. Under the maintained assumptions, the market is always fully covered. This means that maximizing social welfare is simply a matter

[3] Formally, this amounts to ensuring that the location of the consumer who is indifferent between buying from the firm and not buying at all, is beyond the market of the firm.

of minimizing the aggregate travel costs of the consumers. It is straightforward to establish the socially optimal market shares, by equating the social surplus from consuming the two products for a threshold consumer located at z^*. In particular, by letting

$$v - c_X - k(z^* - x) = v - c_Y - k(y - z^*) \tag{12}$$

This means that the socially optimal market shares are determined by

$$z^* \equiv \frac{c_Y - c_X + k(x+y)}{2k} \tag{13}$$

Using the location of the indifferent consumer z, it follows that any pair of prices (p_X, p_Y) that satisfies $z = z^*$, i.e. such that

$$\frac{p_Y - p_X + k(x+y)}{2k} = \frac{c_Y - c_X + k(x+y)}{2k} \tag{14}$$

implements the social optimum. This condition reduces to the requirement that

$$p_X - c_X = p_Y - c_Y \tag{15}$$

That is, the two firms must have identical markups. One special case of this is the competitive solution where $p_X = c_X$ and $p_Y = c_Y$. But it should be emphasized that this is only one of a continuum of solutions to the planner's problem in the present setup.

To make things interesting, I will assume that

$$c_X + k \geq c_Y \tag{16}$$

This assumption means that Firm X is not a natural monopolist and that it is thus socially optimal for Firm Y to serve *some* consumers.

Although the assumption of full market coverage will be made throughout, it is useful to note some features of the socially optimal degree of market coverage. In a geographically unrestricted market served by a single firm, the social planner would price at marginal (production) cost. At this price, the marginal benefit of consumption of the last consumer reached, equals the marginal cost of serving this consumer (including the transport cost that this entails). In contrast, the profit maximizing monopolist would price above marginal cost, thereby serving only half of the socially optimal number of consumers. Details of these results can be found in Appendix C.

4. THE REGULATORY EQUILIBRIA

To solve for the equilibria of the game played between the two regulators, the game is solved backwards. That is, first I determine the equilibrium outcomes in the market subgames at stage 2, for fixed choices of regulatory regimes chosen at stage 1. I then move to stage 1 and determine the equilibrium choices of regulatory regime.

4.1. Best Responses at Market Stage. At the market stage, the two unregulated firms' best response functions are given by

$$p_X^F(p_Y) = \frac{p_Y + c_X}{2} + \frac{k(x+y)}{2} \tag{17}$$

$$p_Y^F(p_X) = \frac{p_X + c_Y}{2} + \left[k - \frac{k(x+y)}{2}\right] \tag{18}$$

The superscript F denotes that the price is chosen to maximize the firm's objective. As usual in this type of model, the reaction functions are upward-sloping (i.e. prices are strategic complements). Furthermore, the presence of travel costs $k \geq 0$ enable the firms to raise their prices above the competitive level. Note that these functions are independent of the location of the border b.

I next consider the pricing behavior of regulated firms. The best responses of the regulators at the market stage (when they have committed at stage 1 to regulate), are given by

$$p_X^R(p_Y) = \frac{p_Y + c_X}{2} + \frac{k(x+y)}{2} - kb \tag{19}$$

$$p_Y^R(p_X) = c_Y \tag{20}$$

The superscript R denotes that the price is chosen to maximize the regulator's objective.

The best response functions are illustrated in Figure 3. The equilibrium prices corresponding to the different regulatory regimes (N,N), (R,R), (N,R) and (R,N) are listed in Appendix A.

It is interesting to note that although the best response of Regulator X is uniformly below that of Firm X, the best responses of Regulator Y and Firm Y cannot be similarly ranked. In particular, whereas for some parameter choices and the rival's price p_X it is indeed the case that Regulator Y is more aggressive than Firm Y, for others the best response functions intersect.[4]

Last, note that of the four best response functions at the market stage, only that of Regulator X depends on the location of the border b.

Below, I will carefully compare the market stage best responses of each country's regulator with that of its unregulated firm.

The Incentives of Regulator X. Consider first the problem of Regulator X. It is interesting to note that Regulator X is always at least as aggressive at the pricing stage as the unregulated Firm X. This is seen by the fact that the only difference between the best response functions is the additional term $-kb$, causing a left-ward shift in (p_X, p_Y)-space in Regulator X's reaction function.

The reason for this shift can be seen from noting that the objective function of Reg-

[4]In particular, Regulator Y is more aggressive at the market stage than Firm Y when $p_X \leq c_Y + k(x+y-2)$.

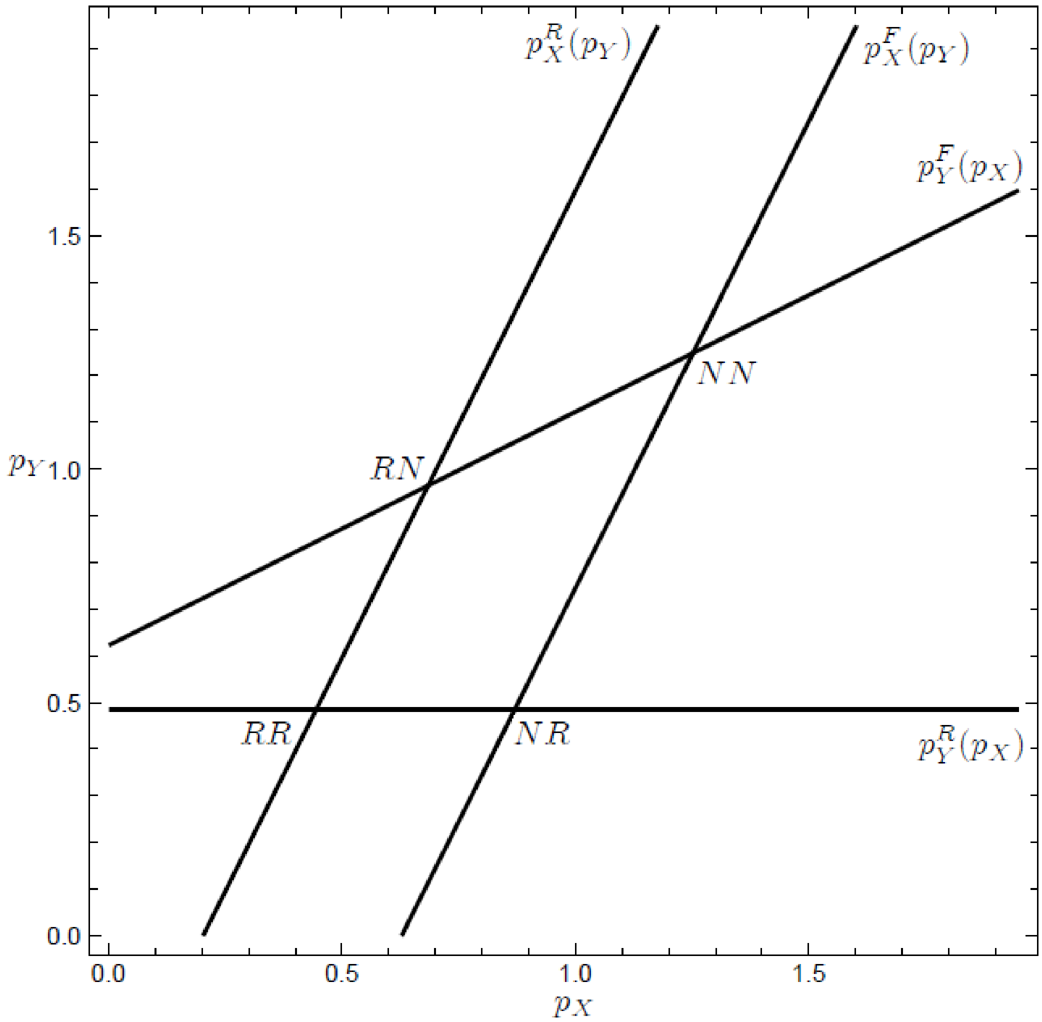

Figure 3: Best responses of firms and regulators in (p_X, p_Y)-space and equilibria at market stage.

ulator X can be rewritten as

$$w_X = \left\{ b(v - c_X) - \frac{k}{2}\left[x^2 + (b-x)^2\right] \right\} + (z-b)(p_X - c_X) \tag{21}$$

The term in curly brackets represents social welfare in Country X, net of income from exports. In particular, this corresponds to the usual difference between the consumers' willingness to pay and production costs, multiplied by the quantity, and an additional term capturing the travel costs of consumers in Country X. Importantly, this term does not depend on the price p_X, a consequence of the fact that there is full market coverage. The second term in the objective function of Regulator X corresponds to the profit of an unregulated Firm X maximizing profits earned on the competitive segment $[b, y]$, of which it captures the sub-segment $[b, z]$.

Next, note that from the perspective of the regulator, as there is full market coverage, it is of no importance what the relative magnitudes of consumer surplus cs_X and the part of profits π_X that accrue on the home market are. From a social perspective, on the home market $[0, b]$, the price p_X simply reallocates surplus between the producer and the consumers and has no influence on aggregate travel costs (in the home country), as was the case for Country X under autarky. This is because the effects of price changes (of either firm) only impact the degree of market coverage in Country Y and all Country X consumers buy from Firm X. In short, from the regulator's perspective, any price will do on this count, in particular the profit maximizing price preferred by the firm.

In addition to the social welfare that accrues on the domestic market, the regulator is also interested in the profits accruing to Firm X on the segment $[b, z]$, i.e. from the exports. Of course, this is true also for the firm, but the key thing to note is that the regulator and the firm disagree on the value of a marginal decrease in price. Because the regulator does not care about the effects of price p_X on the segment $[0, b]$, it sets the price solely to maximize the profits from exports.

The firm, in contrast, maximizes profits from both the home market $[0, b]$ and from exports to $[b, z]$. Crucially, the firm's profits on the home segment $[0, b]$ depend on the chosen price. In particular, any price decrease that boosts profits from exports by expanding the segment $[b, z]$ comes at the expense of decreasing earnings on all inframarginal sales on segment $[0, b]$, which are ignored by the regulator. This is most clearly seen by re-writing Firm X's profits as

$$\pi_X = b(p_X - c_X) + (z - b)(p_X - c_X) \tag{22}$$

and noting that the second term is identical to the second term in Regulator X's objective, whereas the first term is increasing in the price p_X (and the first term in Regulator X's objective is a constant).

For this reason, the regulator prices more aggressively than would the unregulated firm. Note that this is not simply the traditional finding that a regulator would price lower than a firm to expand sales. In this setting, the gross social surplus in Country X is independent of Firm X's price p_X, as are total travel costs.

Last, note that an increase in p_Y not only increases the profits of Firm X (i.e. there are positive spillovers), but it also increases Firm X's incentive to increase its price p_X (i.e. there are strategic complementarities in the two prices in Firm X's optimization problem). These properties are inherited by Regulator X's objective function.

The Incentives of Regulator Y. Next, turn to the problem of Regulator Y. His objective can be rewritten as

$$w_Y = \left[(1-b)v - \frac{k}{2}(1-y)^2\right] - [(1-z)c_Y + (z-b)p_X] \tag{23}$$

$$-\frac{k}{2}\left[(y-z)^2 + (z-b)(b+z-2x)\right] \tag{24}$$

The two terms in the first bracket correspond to the total willingness to pay in Country Y, minus the travel costs incurred by consumers on Firm Y's home turf $[y, 1]$. None of these depend on the prices set by the firms. The expression in the second term is the total cost of supplying the good to the consumers in Country Y and constitutes a classical "make or buy" decision of the marginal unit for Regulator Y. That is, the regulator can either choose to buy the marginal unit at p_X from Firm X (by importing it) or produce it itself via the domestic Firm Y at marginal cost c_Y. The expression in the third bracket corresponds to the total travel costs on the competitive segment $[b, y]$.

This expression simply shows that in deciding on the location of the marginal consumer z, Regulator Y must trade off the travel costs of consumers on segment $[z, y]$ with those on segment $[b, z]$, who buy from the other country's firm. In short, the choice of price for Regulator Y simultaneously influences the cost of supplying to Country Y consumers and their travel costs. Whereas the former is decreasing in p_Y, the latter is increasing in p_Y. These tradeoffs are optimally resolved when Regulator Y prices at marginal cost. Incidentally, this is the same price chosen by an unrestrained social planner, i.e. one that chooses the optimal degree of market coverage (see Appendix C for details).

Last, Firm Y's incentive to increase its price p_Y is increasing in p_X, so the game played between the firms in the free-trade equilibrium is one of strategic complements. But it turns out that this property does not carry over to the market game played between the regulators when they set prices. The reason is that when Regulator Y intervenes, it always prices at marginal cost and its pricing decision is therefore independent of its rival's price p_X. In addition, there are only positive spillovers on Regulator Y's objective from an increase in p_X when the latter is sufficiently high, namely when $p_X \geq c_Y + k(x + y - 2b)$.

4.2. Best Responses at Regime Choice Stage. By substituting the market stage best responses into the regulators' objective functions, the best response correspondences at the regime choice stage can be derived. They are given by

$$a_X(a_Y, b) = \begin{cases} R \text{ if } a_Y = R \\ R \text{ if } a_Y = N \text{ and } b \geq b_1 \\ N \text{ if } a_Y = N \text{ and } b < b_1 \end{cases} \tag{25}$$

$$a_Y(a_X, b) = \begin{cases} R \text{ if } a_X = R \text{ and } b \leq b_3 \\ N \text{ if } a_X = R \text{ and } b > b_3 \\ R \text{ if } a_X = N \text{ and } b \leq b_2 \\ N \text{ if } a_X = N \text{ and } b > b_2 \end{cases} \tag{26}$$

where

$$b_1 \equiv \frac{c_Y - c_X + k(2 + x + y)}{8k} \tag{27}$$

$$b_2 \equiv \frac{c_Y - c_X + k(4 + x + y)}{8k} \tag{28}$$

$$b_3 \equiv \frac{c_Y - c_X + k(4 + x + y)}{6k} \tag{29}$$

It is easily verified that

$$b_1 < b_2 < b_3 \tag{30}$$

As is to be expected, the regulators' best responses at the regime choice stage depend on the size of the two countries, as parametrized by the border b. This dependence will naturally carry over to the equilibrium set to be studied below.[5]

The best responses deserve further discussion. First, consider Regulator X's best response $a_X(R, b)$ and recall that in any market subgame in which Regulator Y chooses to regulate, he sets price $p_Y = c_Y$ (as $p_Y = c_Y$ in both such subgames). This means that Regulator X's two choices yield the market stage equilibria (R, R) or (N, R), as the case may be. Importantly though, they differ only in their values of p_X. as (R, R) lies on Regulator X's market stage best response function and (N, R) does not, the former yields the highest payoff, irrespective of the value of b.[6] In contrast, when Regulator Y chooses not to regulate, Regulator X's best responses depend on the country size b. Finally, Regulator Y's best responses at the regime choice stage always depend on the country size b, irrespective of the choice of Regulator X.

4.3. Equilibrium Outcomes. Using the best responses derived above, the subgame perfect outcomes can be determined. Because the best responses depend on the parameter b, so do the equilibrium outcomes, as the following proposition shows:

Proposition 1. *The equilibrium of the regulatory competition game is as follows:*

$$\begin{aligned} For\ b &\in [0, b_3] : (a_X^*, a_Y^*) = (R, R) \\ For\ b &\in [b_3, 1] : (a_X^*, a_Y^*) = (R, N) \end{aligned}$$

From this result, it follows that the exporting Regulator X will always choose to regulate in equilibrium. An immediate consequence of this finding is that free trade, in which no firms are regulated, is not an equilibrium outcome. On the other hand, the importing Regulator Y will choose to regulate if Country Y is relatively large (i.e. b is sufficiently small) and to not regulate otherwise.

[5] For completeness, it should be noted that Regulator Y is indifferent between his two strategies against $a_X = R$ at both b_3 and at $b_4 \equiv \frac{c_X - c_Y + t(4-x-y)}{2t}$. It is straightforward to show that at most one of b_3 and b_4 can be in the unit interval. Furthermore, a sufficient condition for $b_3 < b_4$ is that $c_X + t \geq c_Y$, which has been assumed to hold.

[6] Another way to see this, is to note that the only reason why Regulator X would want to commit to a point along its rival's best response curve, but not located on its own best response curve, is that the resulting equilibrium prices would increase its welfare. But because $p_Y = c_Y$ whenever Regulator Y chooses to regulate, committing to a point that does not lie on its best response curve does not yield a preferred point.

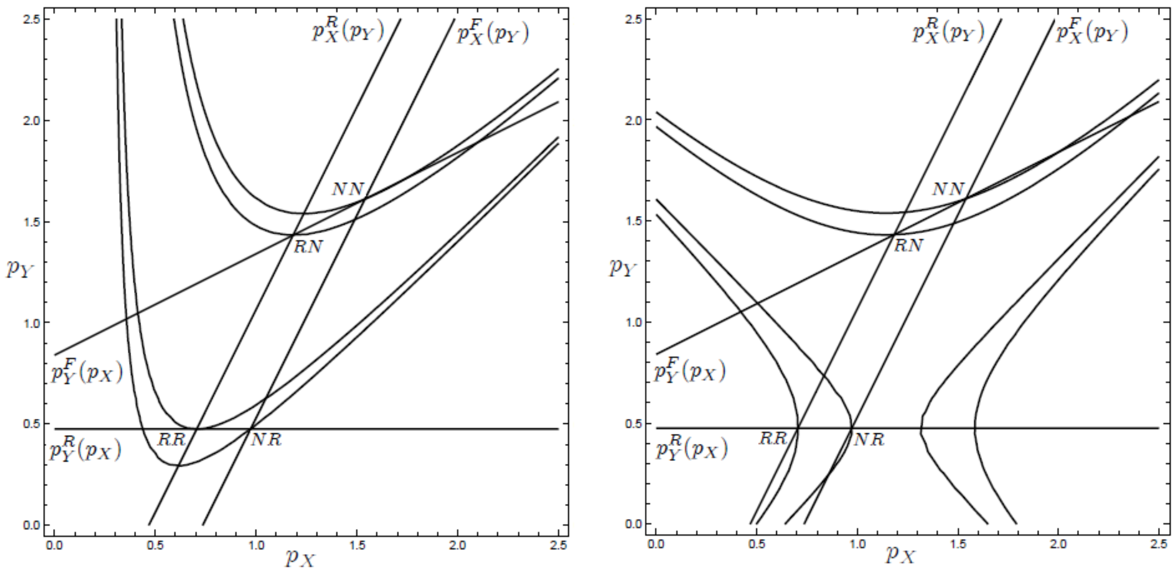

Figure 4: Best responses in (p_X, p_Y)-space at market stage and at regime choice stage. Left-hand side panel corresponds to Country X and right-hand side panel corresponds to Country Y.

Figure 4 shows the best responses in (p_X, p_Y)-space at the market stage and the indifference curves of the two regulators. This figure makes it clear why a regulator may decide to delegate the pricing decision to its firm rather than to set the price itself.

The figure depicts a scenario in which b is relatively low and thus the equilibrium regulatory regime is (R,R). To see this, start by considering the left-hand side panel, which illustrates the preferences of Regulator X. If Regulator Y chooses to regulate, then Regulator X must choose between the points corresponding to (R,R) and (N,R), both located on Regulator Y's market stage reaction curve $p_Y^R(p_X)$. The optimal choice for Regulator X is to choose the point (R,R), i.e. to also regulate, as this point is on a higher indifference curve than the point (N,R). In fact, in this particularly simple example, both points share the p_Y value and so the former must be preferred as it lies on Regulator X's best response curve $p_X^R(p_Y)$.

Next, if Regulator Y chooses not to regulate, then Regulator X must choose between the points corresponding to (N,N) and (R,N), both located on Firm Y's reaction curve $p_Y^F(p_X)$. As the point for (N,N) is on a higher indifference curve than (R,N), the best response for Regulator X is to not regulate. In summary, $a_X(R) = R$ and $a_X(N) = N$. It is worth reiterating that the point (N,N) is not on Regulator X's reaction curve, yet yields a higher level of welfare in Country X than the relevant alternative (R,N), which is on Regulator X's reaction curve. This is exactly the sense in which it can be optimal ex ante for the regulator to commit to something ex post that does not maximize the regulator's objective. Also note that regulation by Regulator Y prompts Regulator X to regulate and thus decrease its price p_X, whereas if Regulator Y does not regulate, then Regulator X will and in doing so, increases its price p_X.

Now turn to the right-hand side panel of the figure, which illustrates the preferences of Regulator Y. Although for this parameterization of the model the indifference map is less well-behaved, the way to read it is similar. In this case, $a_Y(R) = R$ as (R,R) lies on a higher indifference curve than (R,N) and $a_Y(N) = R$ as (N,R) lies on a higher indifference curve than (N,N).

Before presenting a detailed characterization of the equilibrium outcomes, I will briefly consider some comparative statics results. First, as the size b of the exporting country increases (subject to the equilibrium regulatory regime remaining unchanged), the best response of Regulator X shifts leftward in (p_X, p_Y)-space. This means that in the (R,N) equilibrium, both prices p_X and p_Y decrease. In contrast, in the (R,R) equilibrium, only the price p_X decreases (whereas p_Y remains unchanged).

Second, as the magnitude of the transport cost k decreases, the reaction functions of Regulator X and Firms X approach each other and eventually overlap perfectly. This implies that as the transport costs vanish, the (R,N) market equilibrium coincides with the free-trade market equilibrium (N,N). Similarly, the market equilibrium (R,R) approaches the market equilibrium (N,R).

Third, the equilibrium prices are functions of the firm locations x and y. The reaction function of Regulator X is increasing in $(x + y)$, that of Firm Y is decreasing in $(x + y)$, whereas that of Regulator Y is independent of the firm locations. An increase in either location therefore increases the prices charged in the (R,N) equilibrium, whereas in the (R,R) equilibrium, only the price p_X increases (and p_Y remains unchanged).

Last, note that the critical value b_3 is increasing in Firm Y's cost disadvantage $(c_Y - c_X)$. Thus the higher this disadvantage is, the more likely is it that the fully regulated equilibrium (R,R) obtains.

4.4. Characterization of Equilibrium Outcomes. In this section, I will further characterize the different equilibrium outcomes. To simplify the characterization, I will in what follows focus on the symmetric case in which $c_X = c_Y = c$ and $x + y = 1$. Under these assumptions, all remaining asymmetries derive from the location of the border b. Note that for this special case, the critical threshold determining the equilibrium is given by $b_3 = 5/6$. In Appendix D, I list the complete rankings of profits, consumer surplus and country social welfare in all four market subgames.

I will offer several results. First, I will consider the effects that regulatory regime choices have on aggregate social welfare and trade patterns (i.e. exports/imports). Next, I will determine whether the equilibrium choices of the regulators come at the expense of the rival country and are thus of the beggar-thy-neighbour type. Furthermore, I will determine whether the two regulators find themselves in a prisoner's dilemma type game in which each country is worse off in equilibrium than they would be under a free-trade scenario. Last, I will comment on the distributional issues involved in equilibrium regulatory decisions, focusing on profits and consumer surplus within countries, across regulatory scenarios.

For aggregate social welfare, the following ranking can be established:

Proposition 2. *In the symmetric case, the social welfare levels are ranked as follows:*

$$
\begin{aligned}
For\ b &\in [0, 3/10] : W(N,N) > W(R,N) > W(R,R) > W(N,R) \\
For\ b &\in [3/10, 3/4] : W(N,N) > W(R,R) > W(R,N) > W(N,R) \\
For\ b &\in [3/4, 1] : W(N,N) > W(R,R) > W(N,R) > W(R,N)
\end{aligned}
$$

As the only equilibrium outcomes are (R,R) and (R,N), the following result follows immediately:

Corollary 3. *In the symmetric case, equilibrium regulation decisions are never socially optimal.*

Although it is perhaps not surprising that the regulators cannot achieve the first best outcome, they cannot even achieve the best possible market stage equilibrium (N,N). In this sense, the equilibrium is not even constrained socially optimal.

Next, the extent of trade in the different market games can be ranked as follows:

Proposition 4. *In the symmetric case, the locations of the indifferent consumers are ranked as follows:*

$$\begin{aligned} For\ b &\in [0,1/2] : z(R,N) > z(R,R) > z(N,N) > z(N,R) \\ For\ b &\in [1/2,1] : z(R,N) > z(N,N) > z(R,R) > z(N,R) \end{aligned}$$

From these rankings, the following results can be deduced:

Corollary 5. *In the symmetric case, when Regulator X chooses to regulate, it causes an increase in its exports. When Regulator Y chooses to regulate, it causes a decrease in its imports.*

Thus regulation always involves a deterioration of the terms of trade of the regulating country and a corresponding improvement in those of the other country.

Regulation and beggar-thy-neighbor. Next, I will investigate the extent to which the regulatory regime chosen by the regulators in equilibrium is detrimental to welfare in the rival country. In other words, I will determine whether the regime choices constitute beggar-thy-neighbour policies in which the welfare of the home country is increased at the expense of welfare in the other country.

I start by considering the case in which the country size is $b < 5/6$ and thus the unique equilibrium involves the regime (R,R). In this case $w_X(R,R) > w_X(N,R)$ as it must be (as regulating is in this case a best response for Regulator X), but $w_Y(R,R) < w_Y(N,R)$ as long as $b > 1/3$. When Regulator X chooses his best response and regulates, he does so by expanding exports to Country Y relative to the benchmark of not regulating, i.e. $z(R,R) > z(N,R)$. Similarly, $w_Y(R,R) > w_Y(R,N)$ (as regulating is in this case a best response for Regulator Y), but $w_X(R,R) < w_X(R,N)$ for $b < 9/14$. When Regulator Y chooses his best response and regulates, he does so by minimizing imports from Country X, i.e. $z(R,R) < z(R,N)$. In conclusion, equilibrium regulation may in this case involve beggar-thy-neighbour policies, but need not do so. It depends on the magnitude of b.

Next, suppose that the country size is $b > 5/6$. In this case, the unique equilibrium involves the regime (R,N). It is easily verified that $w_X(R,N) > w_X(N,N)$ as regulation is a best response for Regulator X, but now $w_Y(R,N) < w_Y(N,N)$ as long as $b > 1/3$. Thus in this case, Country Y is unambiguously worse off because Regulator X chooses to regulate (and thereby decreases overall welfare in the process). The decision of Regulator X to regulate in this case increases exports relative to the free-trade equilibrium, i.e. $z(R,N) > z(N,N)$. Last, one finds that $w_Y(R,N) > w_Y(R,R)$ as not regulating is the best response for Regulator Y. But because $w_X(R,N) < w_X(R,R)$ for $b > 9/14$, the fact that Regulator Y does not regulate may decrease the welfare in Country X. The decision of Regulator Y not to regulate in fact allows Country X to increase its exports, i.e. $z(R,N) > z(R,R)$. Again, the regulatory choices may involve beggar-thy-neighbour policies, but need not do so.

In conclusion, I have the following result:

Proposition 6. *In the symmetric case, the effect of regulation on the welfare in the rival country is ambiguous. Regulation by Regulator X decreases Country Y welfare when b is sufficiently large, whereas regulation by Regulator Y decreases Country X welfare when b is sufficiently small.*

In other words, regulation by one country decreases the welfare of the other country only when the former is sufficiently large. These observations go some way to rationalize why the WTO rules do not impose a blanket ban on domestic policies, even when these influence trade flows. In effect, such subsidies may increase foreign welfare even when the foreign firm suffers. The key to this is the effect that domestic measures have on the welfare of foreign consumers.

Regulation and the prisoner's dilemma. As previously discussed, in the present model regulation involves an inward shift in the reaction functions more akin to Cournot settings than to Bertrand settings. In third-country models with quantity-setting behavior, it is known that the game played between governments have prisoner's dilemma type features. In other words, in equilibrium, both regulators are worse off than they would be in the free-trade equilibrium. A natural question is whether a similar features holds in the present setting. The answer to this is no. There are no situations in which *both* countries are *individually* worse off in the regulatory equilibrium than they would be in the free-trade equilibrium (as opposed to them being *jointly* worse off, as I have already established they are).

To see this, recall that for $b \in [0, 5/6]$, the equilibrium is (R,R) whereas for $b \in [5/6, 1]$, the equilibrium is (R,N). I will now compare the two countries' social welfare in these equilibria to those in the free-trade equilibrium (N,N):

$$For\ b \in [0, 1/2] : w_X(N,N) > w_X(R,R) \text{ and } w_Y(N,N) < w_Y(R,R) \tag{31}$$

$$For\ b \in [1/2, 5/6] : w_X(R,R) > w_X(N,N) \text{ and } w_Y(R,R) < w_Y(N,N) \tag{32}$$

$$For\ b \in [5/6, 1] : w_X(R,N) > w_X(N,N) \text{ and } w_Y(R,N) < w_Y(N,N) \tag{33}$$

From these rankings, the following result ensues:

Proposition 7. *In the symmetric case, the regulators are never playing a prisoner's dilemma.*

The fact that the regulators are not playing a prisoner's dilemma type game has an important implication for the possibility of establishing a free-trade agreement. As determined above, regulatory coordination is desirable from a global welfare perspective, i.e. the outcome in subgame (N,N) yields the highest aggregate welfare across subgames. This begs the question of whether it would be in the different regulators' interest to cede power to a supra-jurisdictional regulatory authority charged with choosing regulatory regimes with a view to maximizing overall welfare. In a sense, ceding such power is tantamount to committing to not unilaterally choosing to regulate. Had the regulators been involved in a prisoner's dilemma type situation, then both regulators would find it optimal to signs up to a free-trade agreement (conditional, of course, on the rival signing up too). Alas, this is not the case. As just shown, in any equilibrium, one or the other country's welfare would suffer when moving to the free-trade outcome (N,N). This means that in order for a free-trade agreement to be mutually beneficial, it must be supported by additional transfers. The inequalities above show that for $b \in [0, 1/2]$, a transfer from Country X to Country Y would be necessary whereas for $b \in [1/2, 1]$, a transfer in the opposite direction would be necessary. Konishi et al. (2003) study such transfers and show that for a voluntary free-trade agreement to be feasible, countries whose terms of trade improve as a consequence of the agreement, must compensate countries whose terms of trade deteriorate.

Last, from the rankings in Appendix D, it is clear that regulation in a country always benefits the consumers of that country at the expense of its firm. That is, consumers generally prefer outcomes with regulation, whereas firms prefer outcomes with free trade. In this sense, the present model (which explicitly takes into account the effects of regulation on consumer surplus) overturns a standard finding in the strategic trade literature based on third-country models, namely that government intervention allows a firm to make higher profits than it would be able to in a free-trade equilibrium. The reason is that because the regulator cares about the well-being of consumers, this consideration outweighs any incentive that the regulator may have to engage in profit-shifting from the foreign firm to the domestic firm.

4.5. Social Optimality of the Laissez-Faire Outcome. As I have shown above, the free-trade equilibrium in subgame (N,N) yields the highest aggregate level of social welfare of any regulatory regime. This still leaves open the question of whether this market outcome is socially desirable overall. In other words, might laissez-faire bring about socially optimal outcomes? To answer this question, note that under laissez-faire, the equilibrium prices are given by

$$p_X = \frac{1}{3}\left[2c_X + c_Y + k(2 + x + y)\right] \tag{34}$$

$$p_Y = \frac{1}{3}\left[2c_Y + c_X + k(4 - x - y)\right] \tag{35}$$

Furthermore, recall that any prices such that $p_X - c_X = p_Y - c_Y$, induce a socially optimal outcome. Together with the equilibrium prices, this implies that the outcome under laissez-faire is socially optimal when

$$c_Y - c_X = k(1 - x - y) \tag{36}$$

This condition holds in particular (but not only) in the symmetric case, where $c_X = c_Y = c$ and $(x + y) = 1$.

It is worth noting that under this scenario, regulation is not merely socially inferior to laissez-faire. In fact, the unregulated outcome is socially efficient and thus *any* regulation that changes the outcome decreases aggregate social welfare. This is an instance in which uncoordinated regulatory intervention does not merely fail to achieve efficiency. Rather, it actually decreases welfare in a situation in which a laissez-faire policy would achieve the first best outcome.

5. Price Discrimination

In the main analysis, I have maintained the assumption that the exporting firm cannot discriminate between domestic and foreign consumers. I practice, this means that Firm X can set only one price p_X for all consumers, irrespective of their location. I now consider a slight departure from that assumption, by assuming that although Firm X cannot fully price discriminate, it can set two separate prices, namely a uniform price for domestic consumers p_X' and a (possibly) different uniform price p_X for Country Y consumers. Such price discrimination is considered by Rieber (1982).

A little reflection shows that under this scenario, the incentives of Firm X and of Regulator X are perfectly aligned at the market stage. In particular, the firm's choice will maximize the regulator's objective. To see this, note that under a two-price regime, the firm's objective can be decomposed into profits from the home market and profits from exports. Because the firm operates under constant marginal costs, the profits from these two sources are completely independent. On the home market, the situation facing the firm is simply that under autarky. Thus the firm can do no better than to extract all the surplus from the most distant home consumer, by setting the autarky price $p_X' = p_X^A$. On the export market, the firm can now set a separate price p_X to maximize the profits from exports.

To see that these prices maximize Regulator X's objective, recall that under autarky, the regulator is indifferent between different prices as long as the market is fully covered. This means that the regulator would not object to autarky prices for home consumers. Turning to the export market, both the firm and the regulator will want to set the price p_X such as to maximize the profits from exports. In conclusion, under the two-price regime (p_X', p_X), Firm X will set the same price p_X on the export market that would maximize Regulator X's objective without price discrimination. The only difference is that home consumers are charged a higher price than before, but this has no implications for decisions pertaining to the export market.

The best response correspondences at the regime choice stage are now changed to

$$a_X(a_Y, b) = \{R, N\} \tag{37}$$

$$a_Y(a_X, b) = \begin{cases} R & \text{if} \quad a_X = R \quad \text{and} \quad b \leq b_3 \\ N & \text{if} \quad a_X = R \quad \text{and} \quad b > b_3 \\ R & \text{if} \quad a_X = N \quad \text{and} \quad b \leq b_2 \\ N & \text{if} \quad a_X = N \quad \text{and} \quad b > b_2 \end{cases} \tag{38}$$

In other words, compared to the case with non-discriminatory pricing, Regulator X is now indifferent between his strategies. This modification of the best responses essentially leaves the potential equilibria (R, R) and (R, N), which coincide with the equilibria (N, R) and (N, N), respectively.

It is of some interest to consider the possibility that Regulator Y imposes an import tariff $r_Y \geq 0$ on any units that Firm X sell to Country Y. Like price discrimination, such a tariff drives a wedge between the price Firm X can charge its own consumers and the price it can charge foreign consumers. The crucial difference though, is that the extent of that wedge is controlled by Regulator Y, who also collects any revenues arising from the imposition of the tariff.

6. Implementation and Third-Country Benchmark

In the analysis above, I have for simplicity considered a situation in which regulators who choose to intervene do so directly by setting the price of the firm in its jurisdiction. But this is less restrictive than it may appear. In particular, consider the regulation of Firm X. As was explained in detail above, Regulator X's objectives at the market stage are maximized by a parallel shift in the firm's reaction curve. Such a shift can also be achieved by offering the firm a production subsidy $s \geq 0$ per unit produced, with the magnitude of s judiciously chosen to align the firm's reaction curve with subsidies to that of the regulator. Such a subsidy can be financed through non-distortionary taxation. Turning to Firm Y, the subsidy scheme needed to align its incentives with those of Regulator Y is a bit more complicated, as it needs to both shift and pivot the firm's reaction function.

The solution is to offer a subsidy scheme that is a function of the price p_X charged by the rival. Specifically, I have the following result:

Proposition 8. *The following per unit subsidies induce the firms to price exactly like their respective regulators would when they choose to regulate:*

$$s_X^* = k2b \quad (39)$$

$$s_Y^* = k(2 - x - y) + (p_X - c_Y) \quad (40)$$

It is worth noting that although Regulator X can induce Firm X to maximize social welfare in Country X by offering a simple subsidy, Regulator Y may have to tax Firm Y to induce it to maximize social welfare in Country Y. Also note that the tax/subsidy scheme offered to Firm Y shifts up or down depending on the price offered by Firm X. As is clear from the proposition, the subsidies to Firm Y are commensurate with the cost advantage that Firm Y has over Firm X in supplying to the marginal Country Y consumer. Note also that whereas the subsidy to Firm X is proportional to the size of Country X and independent of firm locations, the subsidy/tax offered to Firm Y is independent of country sizes but instead depends on firm locations (though it will be a function of b in equilibrium through the dependence on p_X).

It should be emphasized that the subsidies in the proposition implement the best responses and are therefore (privately) optimal interventions in the space of all possible interventions. To be specific, the approach I have adopted is to first derive the reaction functions of the regulator in (p_X, p_Y)-space and then to find the simplest way to implement these reaction functions via per-unit subsidies. In contrast, the usual approach in the literature is to assume a particular form of the intervention, say subsidies or tariffs, and then optimize within this class of interventions. Needless to say, using this latter approach does not ensure the optimality of the resulting policies.

For completeness, it should be emphasized that the subsidies s_X^* and s_Y^* are different from the subsidies that would result if the regulators committed ex ante to linear subsidy schemes to maximize the sum of domestic social welfare and subsidy expenditures. For a derivation of these, see Appendix E.

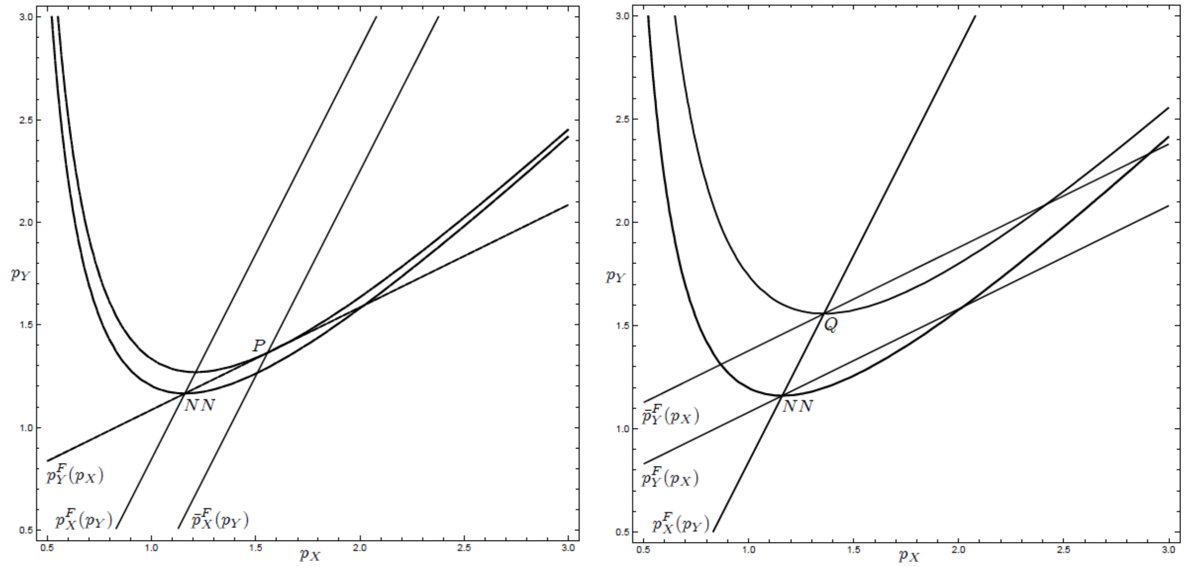

Figure 5: Best responses of firms in (p_X, p_Y)-space at market stage with taxes and indifference map of Firm X. Left-hand side panel corresponds to an increase in t_X and right-hand side panel corresponds to an increase in t_Y.

6.1. Comparison to the Third-Country Benchmark. For comparison, I will briefly consider the equivalent of the third-country setting analyzed in much of the strategic trade literature. Suppose that the setting is as above, but that the two firms are owned (and regulated by) decision makers in other countries, who have no consumers of their own. This is equivalent to the two regulators seeking to maximize the profits of their respective firm while disregarding the welfare of the consumers in the market. In this setting, the location of the border b plays no role, as consumer surplus does not influence the choice of prices.

Suppose that the two regulators impose per unit production taxes $t_X \geq 0$ and $t_Y \geq 0$ on their respective firm. At the market stage, the two firms' best response functions are then given by

$$\bar{p}_X^F(p_Y) = \frac{p_Y + c_X}{2} + \frac{k(x+y)}{2} + \frac{t_X}{2} \tag{41}$$

$$\bar{p}_Y^F(p_X) = \frac{p_X + c_Y}{2} + \left[k - \frac{k(x+y)}{2}\right] + \frac{t_Y}{2} \tag{42}$$

The best responses are illustrated in Figure 5, which also shows the best responses of the untaxed (and unregulated) firms for comparison. To trace the effects of such taxes on welfare, I have also plotted Firm X's indifference map, gross of the production taxes (the indifference map of Firm Y is the mirror image and is therefore omitted).

Start by considering the left-hand side panel, which illustrates the indifference curves for Firm X, when only Firm X is taxed. As the tax t_X is increased, it causes an outward shift in Firm X's reaction function that shifts the equilibrium from the unregulated market equilibrium point (N, N) to the point P. It should be noted that Firm X is made better off by this shift, as can be seen by the ordering of the indifference curves through the points (N, N) and P. Similarly, the right-hand side panel shows the effects of a tax t_Y, which causes an outward shift in Firm Y's reaction function and a corresponding shift from the equilibrium point (N, N) to point Q. Again, Firm X benefits from this shift. The unilateral imposition of taxes thus shifts the equilibrium to either P or Q, whereas the simultaneous imposition of taxes by both regulators, shifts the equilibrium to a third point O, which has higher prices for each firm than in the unilateral taxation cases. These findings are mirror those of the third-country literature.

Now that the mechanical effects of taxes are understood, I will outline why the regulators have an incentive to impose them in the first place. A tax obviously has a direct negative effect on the profits of the firm being taxed, but the revenue raised by the tax can offset this direct loss. Why, then, would a regulator impose a tax that is distributionally neutral? The reason is that by taxing its firm, the regulator helps it commit to higher prices, thereby softening price competition at the market stage. In effect, the regulator allows its firm to behave as a Stackelberg leader vis-à-vis the rival firm. Under Bertrand competition, both firms are better off in the Stackelberg equilibrium than they are in the simultaneous-move Bertrand equilibrium.

Next, I will derive the optimal taxes. These are found by solving the following problem for Regulator $i = X, Y$:

$$\max_{\hat{t}_i}\{\pi_i + q_i\hat{t}_i : p_X = p_X^F(p_Y), p_Y = p_Y^F(p_X)\} \tag{43}$$

where

$$\pi_i = (p_i - c_i - \hat{t}_i)q_i \tag{44}$$

In words, the regulator chooses the tax rate to maximize the sum of revenues raised and its firm's profits at the market stage, anticipating how the firms will react to the imposition of the tax.

The solutions to the regulators' problems are given by the taxes

$$\hat{t}_X = \frac{1}{4}[c_Y - c_X + k(2 + x + y)] \tag{45}$$

$$\hat{t}_Y = \frac{1}{4}[c_X - c_Y + k(4 - x - y)] \tag{46}$$

The equilibrium prices when these taxes are unilaterally imposed by one of the countries, say Country X, are

$$p_X = \frac{1}{2}[c_X + c_Y + k(2 + x + y)] \tag{47}$$

$$p_Y = \frac{1}{4}[c_X + 3c_Y + k(6 - x - y)] \tag{48}$$

The tax imposed on Firm X allows it to charge a higher price than its untaxed rival.[7] The imposition of the tax allows Firm X to commit to prices it would not have been

[7] To ensure that $z \in [b, y]$ in this equilibrium, it must be the case that $(c_X - c_Y)/k \in [8b - 4 - x - y, 7y - x - 4]$.

able to commit to in a regime without intervention. It is therefore of interest to compare the solution under taxation with that under Stackelberg leadership by one of the firms. As shown in a Cournot setting by Brander and Spencer (1985) and in a Bertrand setting by Eaton and Grossman (1986), the equilibrium prices resulting from the unilateral imposition of taxes can be expected to coincide with the outcome under Stackelberg leadership.

When Firm $i = X, Y$ acts as a Stackelberg leader, it solves the problem

$$\max_{p_i \geq 0} \{\pi_i : p_j = p_j^F(p_i)\} \tag{49}$$

It is easily confirmed that the equilibrium prices charged under Stackelberg competition indeed coincide with those under unilateral taxation of one firm. This leads to the following conclusion:

Proposition 9. *When regulators disregard consumers, country welfare is maximized by the unilateral imposition of production taxes.*

This result serves to highlight the stark differences in policy prescriptions that arise from different welfare objectives. When social welfare includes consideration of both consumer and producer surplus, then policy makers will have incentives to induce lower prices, which they can achieve through judiciously chosen subsidies to domestic production. This can lead to aggregate welfare levels that are lower than those in a free-trade equilibrium. In contrast, when regulators ignore the welfare of consumers, then policy makers will have an incentive to induce higher prices, which they can achieve through taxes on production.

For completeness, the prices that are set when both regulators impose taxes are given by

$$p_X = \frac{1}{3}[c_X + 2c_Y + 2k(5 + x + y)] \tag{50}$$

$$p_Y = \frac{1}{3}[c_Y + 2c_X + 2k(7 - x - y)] \tag{51}$$

7. CONCLUSION

The Hippocratic oath famously admonishes medical practitioners to "first do not harm", with the corollary that it is sometimes better to do nothing than to act and make things worse. Although there is no equivalent oath for policy makers, the lesson is valid nonetheless. In their eagerness to do good, implementing regulatory policies to safeguard welfare in a restricted jurisdiction may inadvertently decrease both overall welfare and welfare in the jurisdiction the regulator is seeking to benefit. In formulating regulatory policy, an economic regulator tasked with social welfare maximization may intervene in the market place to carefully trade off the interests of producers with those of consumers. On the other hand, when the market being regulated is interlinked with other (possibly regulated) markets, be that on the producer side or on the consumer side, then regulatory policy becomes inseparable from trade policy. In such settings, regulatory and trade policies must be considered in conjunction and analyzed in a way that explicitly takes into account the strategic interdependency between decisions made by different economic regulators.

As the analysis above clearly shows, the presence of more than one regulator can have effects that are detrimental to overall welfare. This highlights the need for policy coordination that takes overall welfare into account when regulating individual industries.

There are several extensions to the present analysis worth considering. The first is to relax the assumption of full market coverage. Consider a setting in which there is not necessarily full market coverage, but in which the firms still compete. In other words, assume that the home turfs are so large that the firms may not wish to serve all potential consumers. In this case, there is an additional margin on which the firms and the regulators disagree. Under full market coverage, Regulator X is indifferent between different prices on the home market, because these have purely distributional effects and no effects on overall welfare. When the market is not fully covered, this is no longer the case. Specifically, as shown in Appendix C, the regulator will always prefer a lower price than will the firm and hence cover more of the market. But this means that compared to the benchmark of full market coverage, the regulators wants to have even lower prices than the firms. In other words, the qualitative features of the analysis remain valid under this extension.

Second, suppose that the regulators, rather than seeking to maximize overall social welfare, instead sought to maximize only consumer surplus. In this case, Regulator X would disregard the effects of regulation on export profits but would instead insist that Firm X price at marginal cost in order to maximize the surplus of domestic consumers. Similarly, Regulator Y would still insist on marginal cost pricing, as this was optimal even when there was a tradeoff between consumer and producer surplus. Once profits are disregarded, the incentive to price aggressively is even lower than it was previously. It would be interesting to determine whether these changes would materially alter the best responses of the regulators at the regime choice stage and thus whether the equilibrium outcomes would be significantly altered.

Last, I have assumed that regardless of the regulatory regime, the identities of the exporting and importing country was fixed. It would be interesting (but considerably more involved) to analyze the outcomes of the game when a switch in the regulatory regime could change an importing country to an exporting one and vice versa.

Appendix

A. Equilibria of Market Subgames

In this appendix, I list the prices charged in the four possible market subgames that the regulatory choices can give rise to.

A.1. Market Subgame (N, N)**.** In the market subgame (N, N), the equilibrium prices are given by

$$p_X = \frac{1}{3}\left[2c_X + c_Y + k(2 + x + y)\right] \tag{52}$$

$$p_Y = \frac{1}{3}\left[2c_Y + c_X + k(4 - x - y)\right] \tag{53}$$

The remaining equilibrium quantities follow by simple substitution. To ensure that $z \in [b, y]$ in this equilibrium, it must be the case that

$$\frac{c_X - c_Y}{k} \in [2 + x - 5y, 2 + x + y - 6b] \tag{54}$$

A.2. Market Subgame (R, R). In the market subgame (R, R), the equilibrium prices are given by

$$p_X = \frac{1}{2}[c_X + c_Y + k(x + y - 2b)] \tag{55}$$
$$p_Y = c_Y \tag{56}$$

The remaining equilibrium quantities follow by simple substitution. To ensure that $z \in [b, y]$ in this equilibrium, it must be the case that

$$\frac{c_X - c_Y}{k} \in [2b + x - 3y, x + y - 2b] \tag{57}$$

A.3. Market Subgame (N, R). In the market subgame (N, R), the equilibrium prices are given by

$$p_X = \frac{1}{2}[c_X + c_Y + k(x + y)] \tag{58}$$
$$p_Y = c_Y \tag{59}$$

The remaining equilibrium quantities follow by simple substitution. To ensure that $z \in [b, y]$ in this equilibrium, it must be the case that

$$\frac{c_X - c_Y}{k} \in [x - 3y, x + y - 4b] \tag{60}$$

A.4. Market Subgame (R, N). In the market subgame (R, N), the equilibrium prices are given by

$$p_X = \frac{1}{3}[2c_X + c_Y + k(x + y + 2 - 4b)] \tag{61}$$
$$p_Y = \frac{1}{3}[2c_Y + c_X - k(x + y + 2b - 4)] \tag{62}$$

The remaining equilibrium quantities follow by simple substitution. To ensure that $z \in [b, y]$ in this equilibrium, it must be the case that

$$\frac{c_X - c_Y}{k} \in [2 + 2b + x - 5y, 2 + x + y - 4b] \tag{63}$$

B. MOST PREFERRED POINTS

In this appendix, I derive the most preferred points of the two firms in (p_X, p_Y)-space. For each firm, the most preferred point is that in which it captures the entire competitive segment $[b, y]$ at its autarky price.

Define the prices

$$p''_Y = v - k(x-y) - k\max\{x, b-x\} \quad (64)$$
$$p''_X = v + k(x+y-2b) - k\max\{y-b, 1-y\} \quad (65)$$

The most preferred point for Firm X is then (p^A_X, p''_Y), whereas the most preferred point for Firm Y is (p''_X, p^A_Y). Note that for Firm X, any price $p_Y \geq p''_Y$ would be as good, whereas for Firm Y, any price $p_X \geq p''_X$ would be as good.[8]

C. SOCIALLY AND PRIVATELY OPTIMAL MARKET COVERAGE

In this appendix, I determine the socially optimal degree of market coverage for an unrestrained monopolist located at the origin and facing a potential market of consumers uniformly distributed on $[0, \infty]$. The location of the last customer who buys is given by

$$\overline{z} \equiv \frac{v-p}{k} \quad (66)$$

Social welfare is then given by

$$W = (p-c)\overline{z} + \int_0^{\overline{z}} (v - p - ks)ds \quad (67)$$
$$= (v-c)\left(\frac{v-p}{k}\right) - \frac{k}{2}\left(\frac{v-p}{k}\right)^2 \quad (68)$$

The first term is the gross social surplus and the second term corresponds to aggregate travel costs. The first-order condition for optimality then yields the socially optimal price

$$p^* = c \quad (69)$$

The socially optimal degree of market coverage is then given by

$$\overline{z} = \frac{v-c}{k} \quad (70)$$

Rearranging, this equation shows that the socially optimal degree of market coverage is such that

$$v = k\overline{z} + c \quad (71)$$

That is, it is such that for the last consumer to be served, the marginal social benefit of consuming one unit of the good equals the marginal social cost of providing it (including transport costs).

For comparison, consider the market coverage chosen by a profit maximizing firm. The first-order condition yields the price

$$p^M = \frac{v+c}{2} \quad (72)$$

[8] Note that for $z \leq y$, it must be the case that in equilibrium, $p_Y - p_X \geq k(y-x)$. That is, the mill price difference must be larger than the transport cost difference.

which is higher than p^* as $v > c$. This price gives rise to market coverage

$$\tilde{z} = \frac{v - c}{2k} \tag{73}$$

In other words, the profit maximizing firm chooses to serve exactly half the amount of customers that the social planner would serve.

D. RANKINGS OF PROFITS, CONSUMER SURPLUS AND COUNTRY WELFARE LEVELS

In this appendix, I offer a complete ranking of profits, consumer surplus and country level social welfare across the different subgames, for the symmetric case $c_X = c_Y = c$ and $x + y = 1$.

The profit levels are ranked as follows:

$$For\ b \in \left[0, 3(\sqrt{7}-1)/8\right] : \pi_X(N,N) > \pi_X(N,R) > \pi_X(R,N) > \pi_X(R,R) \tag{74}$$

$$For\ b \in \left[3(\sqrt{7}-1)/8, 1\right] : \pi_X(N,N) > \pi_X(R,N) > \pi_X(N,R) > \pi_X(R,R) \tag{75}$$

$$For\ b \in [0,1] : \pi_Y(N,N) > \pi_Y(R,N) > \pi_Y(N,R) = \pi_Y(R,R) \tag{76}$$

The consumer surplus levels are ranked as follows:

$$For\ b \in [0,3/8] : cs_X(R,R) > cs_X(N,R) > cs_X(R,N) > cs_X(N,N) \tag{77}$$

$$For\ b \in [3/8,1] : cs_X(R,R) > cs_X(R,N) > cs_X(N,R) > cs_X(N,N) \tag{78}$$

$$For\ b \in [0,1/3] : cs_Y(R,R) > cs_Y(N,R) > cs_Y(R,N) > cs_Y(N,N) \tag{79}$$

$$For\ b \in [1/3,9/11] : cs_Y(N,R) > cs_Y(R,R) > cs_Y(R,N) > cs_Y(N,N) \tag{80}$$

$$For\ b \in \left[9/11, (2\sqrt{10}-1)/6\right] : cs_Y(N,R) > cs_Y(R,R) > cs_Y(N,N) > cs_Y(R,N) \tag{81}$$

$$For\ b \in \left[(2\sqrt{10}-1)/6, 1\right] : cs_Y(N,R) > cs_Y(N,N) > cs_Y(R,R) > cs_Y(R,N) \tag{82}$$

The country social welfare levels are ranked as follows:

$$For\ b \in [0,3/8] : w_X(N,N) > w_X(R,N) > w_X(R,R) > w_X(N,R) \tag{83}$$

$$For\ b \in [3/8,1/2] : w_X(R,N) > w_X(N,N) > w_X(R,R) > w_X(N,R) \tag{84}$$

$$For\ b \in [1/2,9/11] : w_X(R,N) > w_X(R,R) > w_X(N,N) > w_X(N,R) \tag{85}$$

$$For\ b \in [9/11,3/4] : w_X(R,R) > w_X(R,N) > w_X(N,N) > w_X(N,R) \tag{86}$$

$$For\ b \in [3/4,1] : w_X(R,R) > w_X(R,N) > w_X(N,R) > w_X(N,N) \tag{87}$$

$$For\ b \in [0,1/3] : w_Y(R,R) > w_Y(N,R) > w_Y(R,N) > w_Y(N,N) \tag{88}$$

$$For\ b \in [1/3,1/2] : w_Y(N,R) > w_Y(R,R) > w_Y(N,N) > w_Y(R,N) \tag{89}$$

$$For\ b \in [1/2,5/8] : w_Y(N,R) > w_Y(N,N) > w_Y(R,R) > w_Y(R,N) \tag{90}$$

$$For\ b \in [5/8,5/6] : w_Y(N,N) > w_Y(N,R) > w_Y(R,R) > w_Y(R,N) \tag{91}$$

$$For\ b \in [5/6,1] : w_Y(N,N) > w_Y(N,R) > w_Y(R,N) > w_Y(R,R) \tag{92}$$

E. Maximizing Over Per Unit Subsidies

In this appendix, I consider the subsidies that emerge if each regulator is restricted to interventions that consist of fixed per unit subsidies. Suppose that the two regulators offer per unit production subsidies $s_X \leq 0$ and $s_Y \leq 0$ to their respective firm. At the market stage, the two regulated firm's best response functions are then given by

$$\bar{p}_X^R(p_Y) = \frac{p_Y + c_X}{2} + \frac{k(x+y)}{2} - kb - \frac{s_X}{2} \quad (93)$$
$$\bar{p}_Y^R(p_X) = c_Y - s_Y \quad (94)$$

To derive the optimal per unit subsidies, Regulator $i = X, Y$ solves the problem

$$\max_{\hat{s}_i}\{w_i - q_i\hat{s}_i : p_X = p_X^F(p_Y), p_Y = p_Y^F(p_X)\} \quad (95)$$

where profits are calculated taking into account the presence of subsidies, i.e.

$$\pi_i = (p_i - c_i + \hat{s}_i)q_i \quad (96)$$

The subsidies that solve this problem are given by

$$\hat{s}_X = \frac{1}{4}[c_X - c_Y - k(2 + x + y - 12b)] = -\hat{t}_X + 3b \quad (97)$$
$$\hat{s}_Y = 2k(1-b) \quad (98)$$

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